NUI Galway
OÉ Gaillimh

Semester 2 Examinations 2016/17

Exam Code(s)	4BCT
Exam(s)	4th Year B.Sc. (CS&IT)
Module Code(s)	CT404
Module(s)	Graphics and Image Processing
Paper No.	
Repeat Paper	
External Examiner(s)	Dr. J. Power
Internal Examiner(s)	Dr. M. Schukat * Dr. S. Redfern
Instructions:	Answer any three questions. All questions carry equal marks.
Duration	2 hours
No. of Pages	5
Discipline(s)	Information Technology
Course Co-ordinator(s)	

Requirements:

MCQ	Release to Library:	Yes	X	No
Handout				
Statistical/ Log Tables				
Cambridge Tables				
Graph Paper				
Log Graph Paper				
Other Materials				
Graphic material in colour	Yes		No	

PTO

Q.1. (Graphics)

(i) Explain the concept Nested Coordinate System as it applies to computer graphics. Why are nested coordinate systems useful? [6]

(ii) Provide short sections of code illustrating the use of nested coordinate systems in both Canvas/Javascript, and in X3D [8]

(iii) Antialiasing is an approach in 2D raster graphics, which uses colour (depth) as a means to simulate an increase in resolution. With reference to the 'G' figures illustrated below, discuss the antialiasing technique, and in particular the concept of sub-pixel accuracy. [6]

Q.2. (Graphics)

(i) Describe the use of extrusion in X3D, referring to each of the seven fields used by the Extrusion node. Note that extrusion and other useful nodes from the X3D language are summarised on the final page of this exam paper. [5]

(ii) Write X3D code to make the 3D model of a glass-topped table as illustrated. Note the tapering shape of the legs, and the circular buffers between the legs and the table-top.

Include a diagram of your model showing its measurements, and make the model as geometrically accurate as possible [10]

Define Materials for the model: the legs are a diffuse brown colour, and the top is semi-transparent [5]

Q.3. (Graphics)

(i) What are surface normals? Why are they essential to surface shading algorithms? Refer to Lambert Shading and Gourard Shading. Use diagrams to illustrate your answer. [8]

(ii) Two powerful techniques for rendering shadows in realtime 3D environments are radiosity, and ambient occlusion. Explain these techniques in simple terms, drawing attention to their suitability for pre-runtime computation. [6]

(iii) With respect to 3D graphics rendering, define the terms: specular colour, diffuse colour, ambient lighting. Illustrate each term with a diagram. [6]

Q.4. (Image Processing)

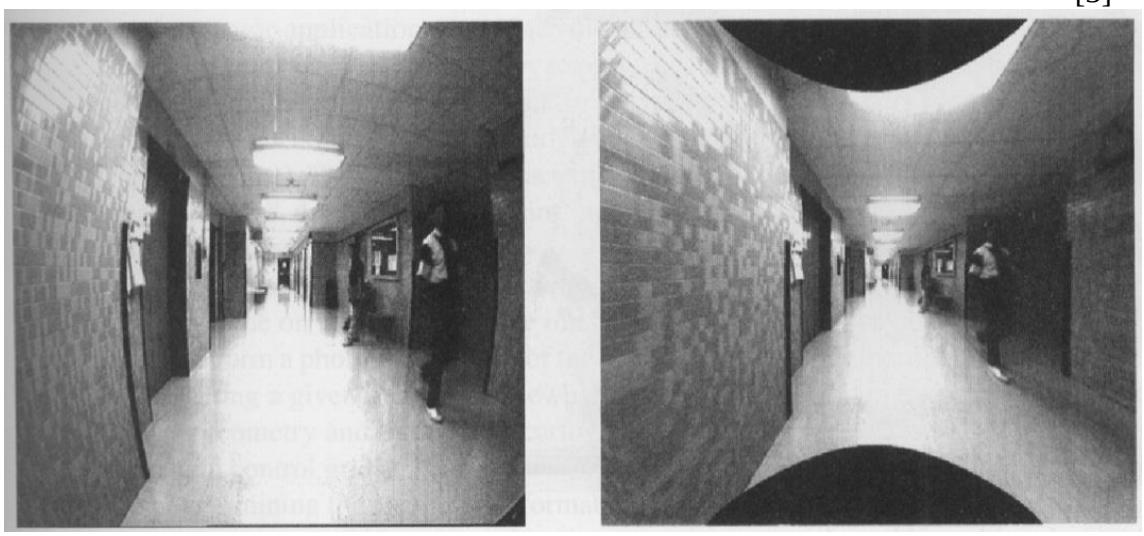
(i) With respect to morphological image processing, outline the following operations: erosion, dilation, opening, and closing, as applied to binary images. [8]

(ii) The image below depicts a number of circular buttons on a table. Outline a suitable series of image processing operations for automatically counting the number of buttons. Explain why your solution is appropriate, and briefly explain the details of each proposed step. You will need to deal with: noise, varying background brightness, the fact that some buttons are touching or overlapping, and the fact that many of the buttons have dark patterns on them. [12]

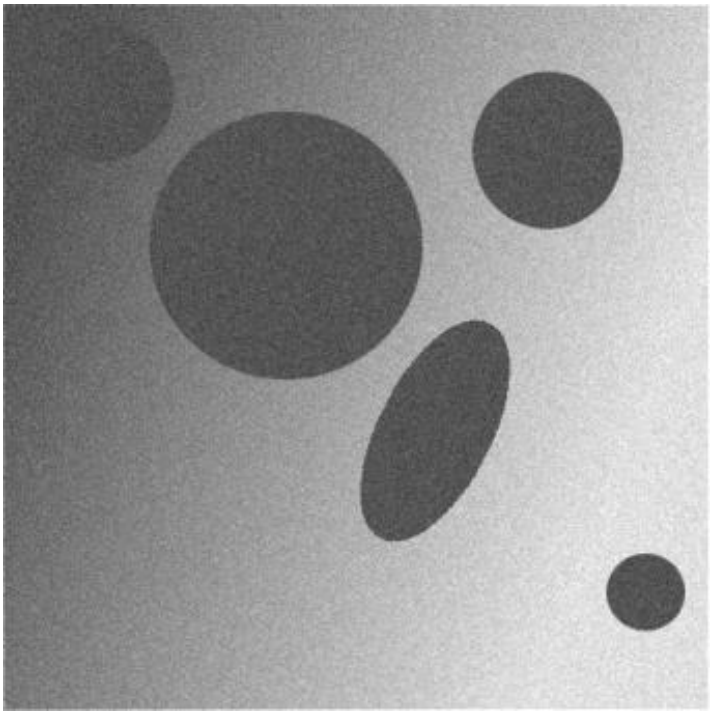
Q.5. (Image Processing)

(i) Camera decalibration is a technique for geometric correction of images which is often employed when sources of geometric error are poorly understood. With regard to camera decalibration:

- Outline the use of reference images such as grids of dots to construct and apply geometric corrections to images captured with a wide-angle lens (e.g. the image below). Use the terms 'control points', 'pixel filling', and 'bilinear interpolation' in your answer. [7]
- Explain why would you expect a reference image to be constructed with black markings on a white background (or white markings on a black background) [3]



(ii) In many cases, it may not be possible to robustly segment an image based on detected edges. One solution is to apply template matching approaches such as the Hough Transform. Explain in simple terms the operation of the Hough Transform as it applies to circles, indicating why it might be a good choice for automatic extraction of circle-like shapes such as those depicted in this noisy image. [10]



Some useful X3D nodes:

Node	Important Fields and Nested Nodes
Shape	Nested Nodes: Appearance, Geometry Nodes (Box, Sphere, Cone, Cylinder, Text, Extrusion, etc.)
Appearance	Nested Nodes: Material, ImageTexture
Material	Fields: diffuseColor, specularColor, emissiveColor, ambientIntensity, transparency, shininess
ImageTexture	Fields: url
Transform	Fields: translation, rotation, scale, center. Nested Nodes: Other Transforms, Shapes, Sensors
TimeSensor	Fields: enabled, startTime, stopTime, cycleInterval, loop
PositionInterpolator	Fields: key, keyValue
OrientationInterpolator	Fields: key, keyValue
Extrusion	Fields: crossSection, spine, scale, orientation, beginCap, endCap, creaseAngle
Box	Fields: size
Sphere	Fields: radius
Cylinder	Fields: radius, height, side, top, bottom
Cone	Fields: height, bottomRadius, side, bottom
PointLight	Fields: on, location, radius, intensity, ambientIntensity, color, attenuation
ROUTE	Fields: fromNode, fromField, toNode, toField

Some useful methods/properties of the Canvas 2D Context object:

Method/Property	Arguments/Values	Notes
fillRect	(Left, Top, Width, Height)	Draw a filled rectangle
beginPath	None	Start a stroked path
moveTo	(X, Y)	Move the graphics cursor
lineTo	(X, Y)	Draw a line from graphics cursor
stroke	None	End a stroked path
fillStyle	="rgb(R,G,B)"	Set fill colour
strokeStyle	="rgb(R,G,B)"	Set line colour
save	None	Save the current coordinate system
restore	None	Restore the last saved coord system
translate	(X,Y)	Translate the coordinate system
rotate	(angle)	Rotate the coordinate system clockwise, with angle in radians
scale	(X,Y)	Scale the coordinate system independently on the X and Y axes